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THE FOOD AND WATER REQUIREMENTS OF *PTINUS TECTUS* BOIELDIEU (COLEOPT., PTINIDAE)

By N. E. HICKIN, Ph.D., F.R.E.S.

INTRODUCTION.

Ptinus tectus Boieldieu has been known to infest a very wide range of substances in this country for well over thirty years. It was originally introduced from Tasmania through commerce and has spread rapidly through Europe. In recent years its range has extended northwards so far as Norway and Finland and it has been recorded fairly extensively in America.

The range of materials that have been attacked by the larvae and in which complete life-cycles have been reared is remarkable. Both vegetable products of high carbohydrate content and animal products of high protein content have been recorded as being infested by the larvae. Grain products, the associated debris and the various cattle foods in which the main constituents are grain products and crushed oil seeds, appear to be the materials most commonly infested. Hayhurst's (1) list of materials from railway warehouses in which adults have been collected contains ninety-six types of such foodstuffs and twelve of them contained larvae. Dried fruit and fruit products such as figs, nutmegs, sultanas, dried apricots and cacao are also extensively attacked. A third group of vegetable substances, which are often recorded as being infested by this species, can be classed as "drugs." Capsicum is frequently attacked, the larva eating the pericarp and leaving the epicarp and seeds uneaten. Cayenne pepper, ginger and leaves and flowers of *Hyoscyamus niger* and *Datura stramonium* also are recorded as larval foodstuffs.

The animal products that are often attacked are dried meat, fishmeal, dried fish, crushed crab, casein and museum specimens of insects. Great damage is done to consignments of industrial casein. Besides the products listed above, the damage to wooden parts of grain elevators, conveyors, etc., occasioned by the larvae hollowing out a position for the cocoon is often considerable.

BIOLOGY.

A number of investigators have reared *Ptinus tectus* in the laboratory. Scholz (2) reared in dried meat a brood which took approximately seven months to pass through the life-history. Von Lengerken (3) reared the species in experimental poultry foods and discussed the choice of place of pupation. Friederichs (4) reared several broods in fish food (which was probably crushed crab) and gave an account of the biology. Fahmy (5) has given an account of the morphology and anatomy of larva and adult and of several aspects of the biology. In particular, the conclusions from his experimental attempts to rear the species in absolutely air-tight containers are interesting. In no case were his attempts successful and thus in the records of this species having bred continuously in "tightly-corked" bottles one must assume that the latter were not hermetically sealed and gas exchange for adequate respiration was possible through diffusion. König's (6) description of the biology of *Ptinus tectus* is the most complete. Considerable emphasis is laid on the

various aspects of the phenomenon of brachyptery which is shown by this species.

In none of the rearing experiments carried out by the investigators cited above was an accurately controlled temperature together with foodstuff in equilibrium with a controlled relative humidity maintained. This disability was removed in the series of rearing experiments which are described below.

Identification. A systematic account of the PTINIDAE of economic importance has recently been published by Hinton (10). *P. tectus* adults are approximately 3 mm. in length but a certain variation in size was observed among the several thousands which I reared. Several individuals were little more than 2 mm. in length, whereas others were over 4 mm. It may be mentioned that the size of the adult is no indication of sex. Of the six smallest adults which were bred, four turned out to be males and two to be females. On the other hand, some males were exceptionally large. No external differences between the sexes has so far been observed. Macropterous types frequently showed the tips of the wings projecting from the distal end of the elytra.

Adult sex ratio. During the experiments on *P. tectus* a total of 1493 adults was sexed by boiling in caustic potash solution and subsequent dissection of the genitalia with a fine needle. Of this total 795 were found to be males and 698 females, giving 46.8% females and 53.2% males. Fahmy (5) dissected 143 adults and found 48.3% females and 51.7% males.

Habits. The adults run quite rapidly, but when investigating foodstuffs, damp spots, or other adults they move more slowly and deliberately and keep moving their antennae all the time. Only once was any attempt at flight observed. On this occasion a beetle was being transferred from one receptacle to another on a folded piece of paper when it commenced to run about on the paper in an excited manner. When it arrived at the highest point of the paper it opened its elytra and spread its wings. It did not vibrate them, however, and after pausing for about half a second it apparently lost its balance, toppled over, and closed its elytra. This behaviour was repeated four times before it became quiescent. This individual was of a large macropterous type.

All adults readily feign death when disturbed. The legs are held closely to the thorax and abdomen, whilst the antennae are folded back down the ventral surface. The position of legs and antennae during feigned death is exactly that occupied in the pupa. Usually, gentle breathing will cause the beetle to move and if continued it will commence to run. A dead adult is easily differentiated from one feigning death, for its legs are held stiffly erect and the antennae are invariably in a forward position.

The adults are negatively phototropic. When in the light, they shelter under anything convenient, and if confined with a soft foodstuff such as flour, they burrow fairly deeply into it. If a number of adults are confined together they invariably cluster together on the darkest side of the receptacle. Young larvae also, if sifted out of their foodstuff, will immediately try to burrow under debris, etc. On the other hand, the fully fed larvae do not shun light when seeking a position for constructing a cocoon, as they will often crawl considerable distances through lighted areas when searching. In addition they will often construct a cocoon utilising the glass wall of the culture cage as one of its sides even though by so doing light is allowed to fall on the occupant.

—A point which should be observed by investigators using open petri dishes

as breeding receptacles is that *P. tectus* adults can crawl up vertical glass walls if they are damp or dusty, but not if they are kept dry and polished. The adults readily drink water. If a piece of wet cotton wool is offered to them they immediately plunge their mandibles into the moisture and drink. Whilst drinking the antennae are held back over the thorax.

A character which *P. tectus* shares with several other species of PTINIDAE, in larvae and adults, is resistance to periods of cold. Broods of this species are recorded as surviving adverse winter conditions of temperature in an unheated room, when, for three separate weeks, the temperature was below 0° C. and falling to - 2° C. on two occasions (Mansbridge (7)). The habit of burrowing in loose foodstuffs and debris may help to protect these insects from extreme cold, and an experiment was carried out by me to test the resistance of *P. tectus* to cold—no protection being available. Groups of twenty larvae and twenty adults were confined in culture cages and hung up out of doors during December 1938 for seven days and nights. During this period severe winter conditions were experienced, the lowest temperature recorded being - 8° C. and the highest + 2° C. The larvae were quiescent and the adults torpid (not, however, in the death-feigning attitude). After twelve hours at 15° C. both the larvae and adults had recovered. The larvae afterwards developed into normal adults, and the adults used in the experiment afterwards laid eggs.

Experiment. In the experimental work which follows, the influence of a range of foodstuffs on the viability of *P. tectus* was determined by noting the population increase and length of life-cycle. Each of the foodstuffs tested was in equilibrium with a range of relative humidities. The duration of the pupal stage at different relative humidities was also tested.

MATERIALS AND METHODS.

Stock. A stock of *P. tectus* was obtained from the Imperial College Biological Field Station, Slough, through the kindness of Dr. O. W. Richards. These were living in mixed foodstuffs containing crushed maize and oatmeal. Fresh stock cultures were commenced, using wholemeal flour (unsieved) in 1-lb. "honey" jars. Upwards of ten stock cultures of *P. tectus* were maintained in order that the same number of larvae could be taken from each culture for each rearing experiment in order to ensure genetical constancy.

Foodstuffs. The foodstuffs employed in the rearing experiments were plain flour, wholemeal flour, rice flour (ground rice), and casein. Every effort was made to obtain these in as standardised a form as possible. The plain flour, wholemeal flour, and rice flour were purchased from a large firm of retailers, and through the courtesy of the latter I was put in touch with the millers. The plain flour contained proportions of Canadian, Plate, Russian and English wheats which were average at the time of purchase and suited the baking requirements of the Birmingham district. The wholemeal flour consisted of two-thirds No. 1 Manitobas and one-third-English wheats (chiefly red), nothing having been extracted during the milling operations. The ground rice was ground from whole Patna rice with no added ingredients and milled in this country. The casein was a brand of industrial casein of South American origin and known to be liable to infestation by *P. tectus* and other beetles such as *Tribolium* spp. and *Dermestes vulpinus*. All the foodstuffs, before being used in the experiments, were sieved through copper gauze of 60 meshes to the inch.

Water Content of Foodstuffs.

This was determined for the four foodstuffs in equilibrium with a range of relative humidities, its importance having been pointed out by Sayed (8). The method of estimation of the water content was as follows:—Approximately fifty grammes of the foodstuff was placed in a culture cage (of the same type as used in the actual rearing experiments) and the latter placed within a humidity chamber. The temperature was thermostatically controlled at 27° C. for relative humidities of from 10% to 60%, and at 20° C. for relative humidities of from 70% to 90%. A period of two weeks was allowed for the foodstuff to get into equilibrium with the particular relative humidity given by the concentration of the potassium hydroxide solution. About ten grammes of the foodstuff were then weighed in a clean, dry petri dish, the foodstuff being scattered thinly over the bottom of the dish. The petri dish was then transferred to a steam oven for twenty-four hours and, after cooling in a desiccator, the dish was re-weighed and the loss in weight calculated as a percentage on the dry weight of the foodstuff.

The temperature of the petri dish during the twenty-four hours drying of the foodstuff varied between 96° C. and 98° C. The oven was of the type which allowed air currents, due to convection, to draw previously warmed dry air from the exterior and to allow the heated air to escape after passing over the contents of the dish. Consideration of the type of oven which allows of a very efficient movement of air brought about by means of a fan was dismissed as being impracticable in these experiments as, due to the light powdery nature of the foodstuffs used, loss not due to the water content would be bound to occur. A drying period of twenty-four hours in the oven was found to be sufficient in all cases to dispose of free water. More prolonged periods of drying showed small fluctuations in the weight of foodstuff which could not be attributed to loss of free water.

Preliminary experiments showed that two weeks was a sufficient length of time for the foodstuffs to get into equilibrium with the particular relative humidity. At relative humidities of 80% and 90%, however, apparent fluctuations in the amount of water absorbed during three and four weeks are probably due to fungal and bacterial action. The results obtained are tabulated (Table 1). It is seen from these results that, up to 60% relative humidity, casein contains appreciably less free water than wholemeal flour, plain flour, or ground rice. Apart from this, the foodstuffs contain very much the same amount of free water at any given relative humidity.

Apparatus. The culture cages and humidity jars used in the experiments together with a special sieve and mechanical sieving device have already been described (Hickin (9)).

Method of Infesting Foodstuffs.

Since sexual differences in the genitalia may be seen readily in the pupa, the first method of infestation tried was the isolation of pairs of sexed pupae. This involved the breaking open of the tough cocoons and the manipulation of the pupae for sexing. Although extreme care was used, it was found that many pupae died or produced adults which were crippled or delicate. On this account the method was discontinued.

The second method used was the isolation of virgin adults from unbroken cocoons. After emergence from the cocoons the virgin adults were left for one week isolated in the dark in order to mature. A few at a time were then

TABLE 1.

The amount of free water present in the experimental foodstuffs after two weeks in humidity chamber. Percentages calculated on the dry weight obtained after twenty-four hours heating in steam oven.

Temperature, ° C.	Relative humidity	Percentage free water			
		Plain flour	Wholemeal flour	Casein	Rice flour
27	10	6.6	6.2	4.5	6.6
27	20	7.2	7.7	4.9	7.3
27	30	8.8	8.6	6.7	8.9
27	40	10.1	9.9	8.0	10.9
27	50	10.9	11.2	9.1	12.2
27	60	11.1	12.1	9.7	14.4
20	70	14.8	16.3	13.8	16.1
20	80	17.9	—	17.1	18.0
20	90	25.6	29.7	28.2	25.4

released together in a large dish and observed closely. Pairing took place quite readily both in daylight and in artificial (electric) light. With twenty-four beetles under observation for two hours an average of five pairings took place. Males quite readily try to effect coitus with other males. Copulation usually takes about five minutes. The male examines the female closely, tapping her head, thorax and abdomen rapidly with his antennae before mounting; the antennae of both male and female wave gently backwards and forwards during coitus. After copulation the pairs were segregated, each pair being placed in a culture cage containing foodstuff in equilibrium with a specified relative humidity. Although several of the pairs were observed to copulate more than once, no eggs were laid in any of the foodstuffs at any relative humidity. Most of the adults fell on to their backs in the soft foodstuff, and, unable to gain their feet, died in this position.

Attempts to infest the foodstuffs with eggs were unsuccessful. The eggs of this species are sticky, and particles of the foodstuff adhere. Small agglomerates of foodstuff may be mistaken for eggs and, in addition, the eggs are very fragile and often break when the foodstuff is disturbed.

Finally, the method of infestation which proved successful was as follows. Groups of fully grown larvae at the stage just previous to cocoon-making were placed in the culture cages containing foodstuff in equilibrium with a range of relative humidities. In order to obtain a degree of genetical constancy throughout the experiments, not more than six larvae were the progeny of a single parent. This was accomplished by taking larvae from a number of separate and distinct stock cultures. The use of groups of fully fed larvae, besides not suffering from the disadvantages in manipulation as noted above, has several striking advantages. On account of the habit of the larvae of rolling up into a ball when disturbed, they can be transferred to the culture cage without any risk of damage if a camel-hair brush is used. Also, they spend a relatively long time resting before pupation and thus become inured to the environmental conditions before metamorphosis. Finally, as a group of adults hatch out at approximately the same time those running about over the surface of the foodstuff are of value to the others in helping them to regain their feet by running up to investigate the struggling ones.

When the adults, which emerged, died they were removed from the culture cage, softened by boiling in potash solution and the genitalia made out under the microscope.

RESULTS.

Tables 2 and 3 give the number and sex of the adults reared from larvae (Parent generation) in the four foodstuffs in equilibrium with various relative humidities. On no food were any adults produced at relative humidities of 10%, 20% or 30% (27° C.) or at 90% and 100% (20° C.). At the high humidities, the growth of moulds was an important factor. As the larvae were nearly full grown, it is probable that the nature of the food had little influence on the development. This is borne out by the examination of the separate figures, which have therefore been added together.

TABLE 2.

Adults emerging from sets of eighty larvae. (All foods added together.)

Temp.	R.H.	No. of adults			% developed
		♂	♀	Total	
27° C.	40%	3	2	5	6
27° C.	50%	19	18	37	46
27° C.	60%	33	38	71	89
20° C.	60%	13	23	36	45
20° C.	70%	24	24	48	60
20° C.	80%	40	28	68	85
	Totals	132	133	265	55.2

TABLE 3.

Data of Table 2 grouped according to foodstuff.

Foodstuff	No. of adults			% developed
	♂	♀	Total	
Wholemeal . .	43	40	83	69
Plain flour . .	28	29	57	47.5
Casein . . .	34	29	63	52.5
Rice flour . .	27	35	62	52
Totals . . .	132	133	265	55.2

The animals whose emergence is put on record in Tables 2 and 3 were left on food and allowed to breed. The numbers emerging in this generation are shown in Table 4. Besides giving the actual numbers emerging, a figure is given for offspring per ♀ parent; as can be seen from Table 2, the number of female parents differed widely in the various cultures.

TABLE 4.

Temp. R.H.	27° C. 50%			27° C. 60%			20° C. 60%			20° C. 70%			20° C. 80%			Totals		
	♂	♀	no. per ♀	♂	♀	no. per ♀	♂	♀	no. per ♀	♂	♀	no. per ♀	♂	♀	no. per ♀	♂	♀	no. per ♀
Whole- meal. Plain flour .	3	4	1.0	16	7	2.3	9	11	1.22	19	15	4.25	32	31	12.6	79	68	3.7
Casein .	1	0	0.25	9	4	1.3	0	1	0.025	7	4	2.2	22	11	6.6	39	20	2.0
Rice flour .	0	0	—	1	3	0.4	0	0	—	3	1	1.3	8	6	1.6	12	10	0.3
Totals .	4	4	0.4	26	14	1.1	9	12	0.9	48	42	3.75	105	87	6.6	192	159	1.32

Duration of life-cycle.

It was not found practicable to study the duration of a number of individual life-cycles. An indication of the average duration was, however, obtained by finding the difference between the average dates of emergence of parents and offspring (animals recorded in Tables 2 and 4, respectively). These average figures are recorded in Table 5.

TABLE 5.

Temperature R.H.	Average duration of life-cycle in weeks				
	27° C. 50%	27° C. 60%	20° C. 60%	20° C. 70%	20° C. 80%
Wholemeal	16.0	10.5	19.0	21.5	21.0
Plain flour	11.0	—	—	24.0	28.5
Casein	—	16.0	—	29.5	36.0
Rice flour	—	—	—	24.0	25.0
Average	15.4	10.7	19.0	23.3	25.1

1. From the table it may be seen that the shortest average length of life-cycle was 10.5 weeks, which occurred in wholemeal flour in equilibrium with 60% relative humidity at 27° C.

2. The longest average length of life-cycle was 36 weeks, which occurred in casein in equilibrium with a relative humidity of 80% at 20° C.

3. In wholemeal flour, plain flour, and casein the average length of life-cycle was approximately twice as long at 20° C. as it was at 27° C.

4. In plain flour and casein an increase in relative humidity from 70% to 80% at 20° C. increased the average length of the life-cycle. In wholemeal flour the average length of the life-cycle was approximately the same at 70% relative humidity as at 80%.

Length of Life of Pupa at Different Relative Humidities.

In view of the risk of damage to the pupa when a cocoon is opened, use was made of the habit of the larva of utilising the glass sides of the culture cage as one side of the cocoon. In this way the changes from larva to pupa, and from pupa to adult, were observed without disturbing the cocoons. Accordingly groups of approximately 50 larvae were placed in culture cages with plain flour in a humidity chamber of relative humidity 50%. When the larvae had finished making cocoons the contents of the culture cages were tipped out with the exception of cocoons whose contents were visible through

the glass. These cocoons were then numbered on the glass with black indelible ink. The culture cages containing the marked cocoons were placed at different relative humidities and were examined at a fixed time daily. The length of the pupal stage and the length of the adult resting stage before emergence was determined. Table 6 shows the average length of pupal stage and average length of adult resting stage for the range of relative humidity.

TABLE 6.

Length of pupal stage and maturation of adult with varying relative humidity.

Relative humidity, %.	Average length of pupal stage, days	Average length of maturation of adult, days	Average time in cocoon from metamorphosis into pupa	Temp., ° C.
10	All larvae died in cocoons			27
30	All larvae died in cocoons			27
40	12.7	8.3	21.0	27
50	11.3	9.7	21.0	27
60	11.0	7.25	18.25	27
70	13.8	9.5	23.3	20
80	16.1	7.4	23.5	20
90	13.4	10.0	23.4	20

Influence of free water on length of life and reproduction of adults.

Groups of 50 adults which had emerged in the previous 14 days, and had been feeding on wholemeal flour, were isolated into two series. In one, small aluminium tubes $\frac{1}{4} \times 1$ " filled with wet cotton wool were placed in the culture cages, one in each. In the other, there were no tubes of wet cotton wool. The insects were given no food. The cages were then placed in pairs in the humidity chambers and each week the dead were removed and sexed. The humidity control was only approximate because of the wet cotton wool. Table 7 gives the mean survival period of these insects. A number of adults was often to be seen drinking, with mandibles plunged into the wet cotton wool. It may be noted that in all the cages, even those without water, some eggs or larvae were found during the experiment, so the insects may lay even in the absence of foodstuffs.

TABLE 7.

Mean survival period of beetles with and without water (weeks).

Temp. R.H.	27° C. 10%		27° C. 30%		27° C. 60%		20° C. 80%		20° C. 90%	
	+w	-w	+w	-w	+w	-w	+w	-w	+w	-w
♂	5.3	2.8	6.2	3.8	4.0	3.6	13.4	3.0	5.8	7.1
♀	5.9	2.7	7.2	3.7	3.7	4.2	16.0	4.0	8.0	8.4

It may be concluded that without water to drink *P. tectus* survives about three weeks except at very high humidities (90%), when they survive longer. When given water to drink the survival period seems to depend only on temperature and not on relative humidity, but the figures do not allow of any very definite conclusions.

Some experiments were also made to show the effect of free water on the rate of reproduction. Groups of 30 adults which had emerged in the previous

14 days were put in cages with wholemeal and plain flour in equilibrium with various relative humidities at 20° C. A tube of wet cotton wool was put in each cage (placed so that the wool did not touch the flour). Larvae were sieved out of the flour from time to time and the number obtained during 8 months is recorded in Table 8. The high number of offspring may be compared with the low numbers recorded in Table 4 (female without access to free water).

TABLE 8.

R.H.	Food	No. of larvae
40%	Wholemeal	394
50%	Plain flour	265
50%	Wholemeal	909
60%	Plain flour	335
60%	Wholemeal	678

Effect of adding yeast or wheat germ to the foodstuffs.

In the first set of experiments, 5% of yeast powder (by volume) was added to plain flour and casein respectively, and well mixed. Cultures to which yeast had not been added were kept as controls. One set of 4 cultures was kept in equilibrium with 60% R.H. at 27° C., another in equilibrium with 80% R.H. at 20° C. Ten fully fed larvae of *P. tectus* were introduced into each culture and the adults to which these gave rise were allowed to breed and produce a second generation. The results of these experiments are summarised in Table 9.

TABLE 9.

Experiments with added yeast powder. Emergence of generation (see Table 1; with average length of life-cycle.

Relative humidity 60% 27° C.	No. of males	No. of females	Total no. of adults	No. per parent female	Average length of life- cycle
Plain flour	1	4	5	1.2	14 wks.
Plain flour with yeast powder . .	6	1	7	7	10.5
Casein	2	2	4	2	12
Casein with yeast powder . .	29	18	47	9.4	8
Relative humidity 80% 20° C.					
Plain flour	6	3	9	2.2	25
Plain flour with yeast powder . .	24	19	43	10.8	20
Casein	5	6	11	2.8	38
Casein with yeast powder . .	24	18	42	14.0	21

The importance of an addition of yeast to either plain flour or casein is clearly shown both in the increase of offspring per female and in the shortening of the life-cycle. In the experiments with casein and yeast a higher number of offspring per female (at 20° C. 80% R.H.) and a shorter life-cycle (at 20° C. 60% R.H.) were recorded than in any other set of conditions tested.

In a second set of experiments 5% yeast powder by volume was added to pure potato starch and pure casein, one being almost pure carbohydrate, the other pure phosphoprotein. A third mixture was made by adding to potato starch 5% by volume of a substance consisting mainly of wheat germ.

Cages containing pure potato starch and casein, respectively, were kept as controls and the experiment was carried out in duplicate. When the food-stuffs were in equilibrium with 70% R.H. at 20° C., twenty first-stage larvae were introduced into each cage. In Table 10 the average duration of life-cycle and the numbers completing their development are recorded. The effects of the addition of yeast (or wheat germ) to the pure foods is again evident. The few individuals which completed their development in pure potato starch apparently did so by eating the dead bodies of other larvae, for only the head capsules could be sieved out, whereas in casein whole larval skins were obtained.

TABLE 10.

Foodstuffs in equilibrium with 70% relative humidity 20° C. Emergence of adults from infestation with 20 first-instar larvae.

Foodstuff		Number emerged			Average length of time from infestation to emergence in weeks
		Males	Females	Total	
Potato starch	1	0	1	1	16
	2	2	0	2	16
Potato starch with yeast	1	6	11	17	12
powder	2	9	5	14	13
Potato starch with wheat	1	9	4	13	13
germ	2	6	9	15	14
Pure casein	1	4	—	4	20
	2	1	1	2	37
Pure casein with yeast	1	12	6	18	14
powder	2	8	9	17	14

ACKNOWLEDGEMENT.

Dr. O. W. Richards is thanked for his advice and suggestions.

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SOME OBSERVATIONS ON *MONONYX NEPAEFORMIS* (FABRICIUS 1775), A TOAD-BUG (MONONYCHIDAE, HEMIPT.-HETEROPT.)

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MEMBERS of this little-known family of the Cryptocerata (also called GELASTOCORIDAE, NERTHRIDAE, or GALGULIDAE) are for the most part tropical or sub-tropical in distribution. They occur in North, Central and South America, from the United States to the Argentine, in the West Indies, in Australia (New South Wales and Queensland), in the Malay Archipelago (New Guinea, Sumatra), China (Mou-Pin), and also in India.

Apart from the description of the life-history of *Gelastocoris oculatus* Fabricius in the United States by Hungerford (1922 : 145-171), there is practically no published information concerning the ecology of any of the species—though their raptorial front legs indicate that they are all predacious.

Up to the present, the family has been generally regarded as semi-aquatic, frequenting the borders of ponds and streams (Imms, 1938 : 370). Some species occur in stagnant water, and some in fresh (Champion, 1901 : viii), and they frequently have an earthy incrustation which is hard to remove (Champion, 1901 : 350). *Mononyx nepaeformis* in Trinidad, however, does not have such habits, and its habitat would appear similar to that of *M. bipunctatus* Melin taken in Peru (Melin, 1930 : 194).

M. nepaeformis has been taken commonly, both by the writer, and by Dr. H. B. N. Hynes, in a small banana plantation attached to the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, during both the wet and dry seasons of 1941-42. There is neither standing nor running water anywhere in the vicinity of this plantation, and, in the dry season, the ground becomes parched and dry. The insects are most readily found under débris, such as heaps of dry grass or old pawpaw stumps, and seem to spend much of their time burrowing in the soil, where they are common also, though less easily detected, while nymphal exuviae have often been found underground. In the laboratory, too, they will readily burrow in moderately loose soil.

All their time, however, is not spent in this manner, for the writer has swept the species off low vegetation on to which it had climbed, presumably in search of prey.

The food of *M. nepaeformis* consists of small, preferably soft-bodied, insects of various kinds suited to its size of about 7 mm. long. In the laboratory, termites were the most readily accepted and the most hungrily devoured, while small moths and beetles were not received with favour, presumably because of the scales of the former and the hardness of the latter.

In the field, the natural food was not determined, but termites may feature largely in the diet, and probably also a soil-dwelling earwig (*Euborella* sp.) with which *M. nepaeformis* has on several occasions been found associated, and which is readily taken as food in the laboratory.

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M. nepaeformis, when disturbed, will at once feign death by drawing all its legs close to the body, and will remain in that position for several minutes, even when put on its back. Its normal mode of progression is by a series of jerky runs, and it can jump several times its own length with ease. When catching its prey, it stays perfectly still until an opportune moment arrives, and then pounces on its victim, holding it firmly between its strong raptorial front legs. It then inserts its proboscis and sucks the prey dry.

Attempts were made to breed the species in captivity, and mating was observed. The process is for the male to jump on to the back of the female, and to incline himself slightly to the right (*i.e.* abdomen to the left, as observed by Hungerford (1922 : 147) in relation to *G. oculatus*). Unfortunately no eggs were obtained, but last-instar nymphs have been reared through to adults in soil, and the duration of this stadium was found to be at least two weeks. Eggs were not found in the field, but it seems probable that oviposition is similar to that indicated by Hungerford (1922 : 148) for *G. oculatus*.

A single specimen of *M. nepaeformis* was found dead with a fungus (probably *Cordyceps* sp.) growing out of the pronotum.

Thanks are due to Mr. H. G. Barber, of the United States Department of Agriculture Bureau of Entomology and Plant Quarantine, for determining this species, and also *Mononyx montandoni* Melin, which was described from Venezuela (Melin, 1930 : 191).

A male and a female of this latter species, which is about half the size of *M. nepaeformis*, were taken by the writer on the wet mud of a rice seed-bed at St. Augustine, Trinidad, 19.xi.1941.

Three species are thus known from Trinidad, namely, *M. nepaeformis* and *M. montandoni*, already mentioned in the paper; and *M. bipunctatus* Melin. The latter record is based on a specimen in the Museum at Copenhagen (Melin, 1930 : 177).

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A GYNANDROMORPH OF *AËDES AEGYPTI* L. (*STEGOMYIA FASCIATA*), DIPTERA

By W. J. P. SMYLY, B.Sc.

THE occurrence of gynandromorphs amongst mosquitos appears to be comparatively rare. In Britain, only eight cases have been recorded during the past twenty years, the latest case of gynandromorphism having quite recently been reported by Classey from the Army School of Hygiene, Mytchett, Hants. Classey describes the most unusual occurrence of an apparently normal female of *Theobaldia annulata* Schrank possessing a typical male hypopygium. Of the remainder, three cases were provided by Edwards (1917); one by Shute (1926), and three by Marshall from the British Mosquito Control Institute, Hayling Island. Four of the eight were the same species, namely *Aëdes punctor*; and of these, three were caught by Edwards within a period of ten minutes on Harrow Weald Common, Middlesex, and the fourth was provided by Shute. Those recorded by Marshall were *Aëdes detritus*, *Culex pipiens* and *Culex molestus*.

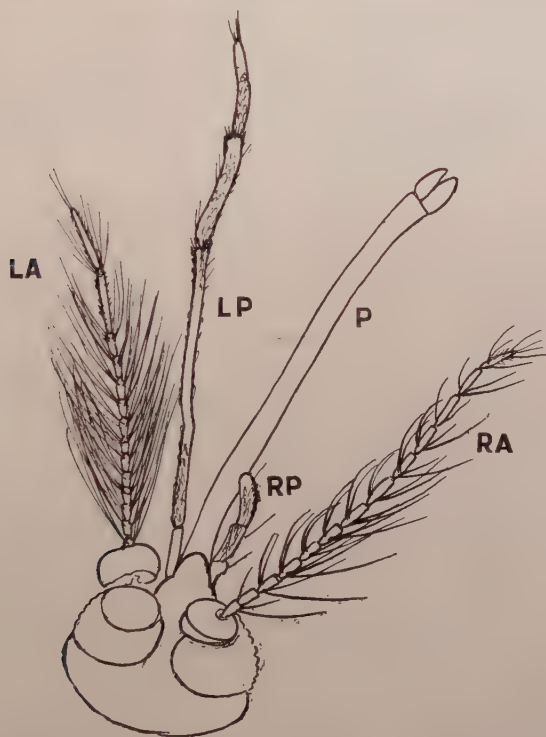


FIG. 1.—Head of a gynandromorph *Aëdes aegypti*. LA, left antenna; LP, left palp; P, proboscis; RP, right palp; RA, right antenna.

The specimen described below was discovered in a stock of *Aëdes aegypti* which has been reared in the London School of Hygiene and Tropical Medicine for a considerable number of years. During an experiment with caged mosquitoes, PROC. R. ENT. SOC. LOND. (A) 17. PTS. 10–12. (DECEMBER 1942.)

to test the effectiveness of a repellent substance smeared on the arm, a mosquito was observed, apparently a male, endeavouring to pierce the skin. At each attempt, however, its proboscis only bent, and on being removed from the cage for closer examination, its peculiar nature was observed.

Description of specimen (fig. 1):—Left antenna, as in male, normal. Right antenna, as in female, normal. Left palp, as long as normal male, but not so hairy. Right palp, as in female, basal joint somewhat enlarged. Hypopharynx, as in female, normal. Right maxilla and mandible, as in female; left maxilla, half the length of normal female, and left mandible missing. Left front claw, as in male, normal; right front claw as in female, normal. External genitalia, male, normal.

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THE HARVESTING OF ALDER BUCKTHORN (*RHAMNUS FRANGULA*) AND THE EFFECT ON THE INSECT FAUNA

By G. FOX-WILSON, N.D.H., F.R.E.S.

AN opportunity of studying the effect of the temporary disappearance of an essential food-plant upon two insect species has arisen in recent months owing to the extensive cutting to ground-level of the Alder Buckthorn (*Rhamnus Frangula*) on commons in the southern and south-eastern counties of England and possibly elsewhere.

This widespread harvesting of Buckthorn arises from the necessity to ensure supplies of home-grown stocks for the Ministry of Supply. The value of the plant lies in the cathartic properties of the bark and the superiority of its wood in the preparation of charcoal.

The insects concerned are the Brimstone butterfly, *Gonepteryx rhamni* L., which is a monophagous species; and the Aphid, *Aphis rhamni* Boyer (*A. abbreviata* Patch),¹ which displays monophagy during the winter phases of its life-cycle.

Lepidopterists may be able to elucidate the problem as to the effect on Brimstone populations of widespread harvesting of Buckthorn, for it is understood that large areas were denuded of this shrub during the last war (1914–1918).

The value of the butterfly is aesthetic : and as a harbinger of spring its absence would be lamentable. The applied entomologist is, however, specially concerned with the importance of the Aphid as a Potato pest and to the fact that this species has been recorded as a vector of Solanum Virus 3 in the United States,² though it has so far not been proved to transmit the disease in this country.

¹ Theobald, F. V., 1927, *The Plant Lice or Aphididae of Great Britain* 2 : 199–202, 404.

² Kenneth Smith, 1937, *Textbook of Plant Virus Diseases*, 353, 521–523.

THE PROBABLE MECHANISM OF PHASE VARIATION IN THE PRONOTUM OF LOCUSTS

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(Imperial Institute of Entomology.)

INTRODUCTION.

ONE of the recognised morphological differences between adults of the solitary and gregarious phases of locusts is in the shape of the pronotum. The difference is particularly striking in *Locusta migratoria* (L.) and is best observed in the profile view, ph. *solitaria* having a definitely convex median carina which, in the ph. *gregaria*, is straight, or even slightly concave (fig. 1). Duarte (1939) has shown experimentally that the degree of convexity of the carina remains unchanged in the solitary phase from the second hopper instar to the adult, and very little difference is observed between the phases in the first three instars, but in the 4th instar the carina in the gregarious phase is perceptibly less convex, and in the 5th it becomes straight in profile. Parallel with the depression of the carina, the pronotum of the ph. *gregaria* becomes distinctly constricted in the middle but broadened in the shoulders, and its metazona becomes relatively shorter and more rounded behind, instead of being angular as in ph. *solitaria*. Since it is known now that the differentiation of the gregarious phase is mainly (and probably even entirely) due to the greater activity in the hopper stage (Faure 1932; Husain and Mathur 1936; Uvarov 1937), the question arises as to the probable connection between activity and the pronotal shape.

Maloeuf (1935) has shown that the configuration of the insect exoskeleton appears to be influenced by the pull of the muscles attached to it, when they contract. If this is the case, then a greater deformation should be expected in a more active phase of the locust, and the morphological changes in the pronotum of the ph. *gregaria* should correspond with the arrangement and the attachment of the thoracic muscles. Moreover, a study of the muscles likely to produce the changes in the pronotum should suggest which kinds of movement may be of particular interest as probable factors of its deformation.

The problem may be attacked from two sides, viz. (1) the anatomical, by a study of the thoracic musculature in relation to the pronotal shape, and (2) the physiological, by a study of the types of movement prevalent in the ph. *gregaria* as compared with ph. *solitaria*. Only the anatomical method can be applied at present, because of the lack of facilities for work with live locusts, and the results are published in the hope of attracting the attention of more fortunately placed investigators.

SKELETON OF THE PROTHORAX.

Before the muscles can be described a brief account of the prothoracic skeleton must be given. Both the skeleton and the muscles of this region in *Locusta* agree closely with those of *Dissosteira carolina* L., described by Snodgrass (1929), and the nomenclature used by him will be retained in the following discussion.

The prothorax is attached to the head by a neck membrane (figs. 2, 3, 4, NM), in which are situated two pairs of cervical sclerites (CS 1, CS 2); it is attached to the mesothorax by an intersegmental membrane (IM). The greater part of the prothorax is covered by the arched pronotum. The edges of the pronotum

are reflected back, both folds being free from the outer wall for a short distance in the dorsal region, but for the rest of their length they are fused with it. The neck and the intersegmental membranes are attached to the true edges of the prothorax, the neck membrane in front of ridge *a* and the intersegmental membrane a little way behind ridge *e* (fig. 2). The pronotum therefore projects slightly over the head in front and to a considerable extent over the mesothorax behind, when the animal is at rest. The extent of the folds is not visible from the outside.

Fig.1

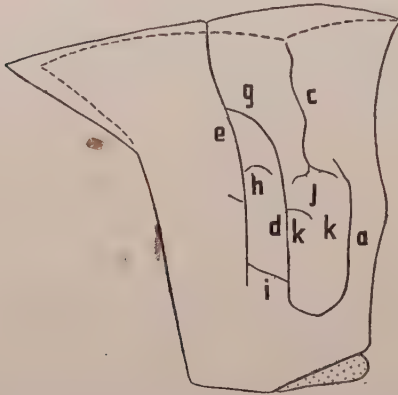
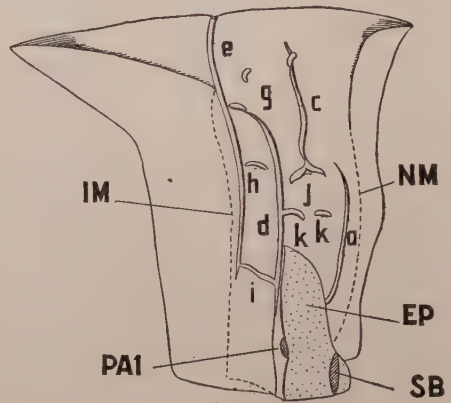


Fig.2



FIGS. 1-2.—1. Outside view of the right side of pronotum of the *ph. solitaria* (dotted line showing dorsal profile of the *ph. gregaria*). 2. Inside view of the left side of pronotum of the *ph. solitaria*.—EP, episternum; IM, intersegmental membrane; NM, neck membrane; PA, pleural arm; SB, skeletal bridge; *a-k*, grooves on the outside and corresponding ridges on the inside.

Various grooves seen on the outer surface of the pronotum (fig. 1) correspond with internal ridges (fig. 2) and it is on, or below, some of these that many of the muscles are inserted. There are four main vertical ridges, *a*, *c*, *d*, *e* (*d*, curving posteriorly at its dorsal end to meet *e*); and several horizontal or oblique ones, *g*, *h*, *i*, *j*, *k*, of which some meet the vertical ones.

The pleura appear externally only as small projections at the base of the pronotum (fig. 1). Internally, however, they can be seen as two plates, the episterna (fig. 2, EP), lying against the lower part of the pronotum immediately in front of the ridge *d*. At its posterior end each plate turns inwards and ends in two projections—a dorsal one, the pleural arm (PA 1) and a ventral one which articulates with the coxa.

The ventral skeleton of the prothorax is formed by the sternum. This consists of two plates, an anterior one bearing two lateral processes, the sternal arms (fig. 4, SA 1), each of which joins with the corresponding pleural arm (PA 1), and a posterior one, which has a median groove externally, corresponding with an internal projection, the spina (SP 1). Anteriorly the sternum is joined with each episternum by a skeletal bridge (fig. 2, SB).

MUSCLES OF THE PROTHORAX.

An account of the musculature of *Locusta* has been given by Maki (1938), but his treatment is brief and his figures purely diagrammatic so that the paper is of little value for our purpose.

The muscles of the prothorax fall into four groups :—

1. *Muscles Moving the Head Directly.*

There are five main pairs of muscles in this group—three towards the dorsal side, one ventral and one ventro-lateral pair. The three dorsal pairs are the 1st and 2nd protergals of the head (fig. 3, 1 *pth*, 2 *pth*), both arising from the dorsal part of the pronotum and running somewhat obliquely downwards, and the dorsal longitudinal pair (*dl*) arising from the 1st thoracic phragma: these are all inserted on the post-occipital ridge of the head. The 1st ventral longitudinal muscle of each side (1 *vl*), arising from the sternal arm, goes to the base of the head. The ventral lateral neck muscle (not shown in the figures) arises from the anterior edge of the episternum and goes to the neck membrane. The head will be raised by the simultaneous contraction of the dorsal muscles and lowered by the contraction of the ventral pairs.

Increased contraction of the protergals would tend to shorten the metazona, for although they are not inserted on the metazona, their effect would be transmitted to this region; as they are situated somewhat obliquely, it would also tend to depress the dorsal carina. The dorsal longitudinal muscles might also have some effect in shortening the metazona, but since the pull would have to be transmitted through the thin intersegmental membrane, their effect would be slight. The ventral lateral muscles, which help in turning the head, would probably have no effect on the changes under consideration. The effect of the 1st ventral longitudinal muscles will be considered later in connection with the 3rd and 4th ventral longitudinal muscles.

2. *Muscles Moving the Cervical Sclerites.*

The cervical sclerites (figs. 3, 4, CS) are moved by five pairs of muscles. Two pairs of cephalic muscles (not shown in the figures) arise from the post-occipital ridge and pass obliquely down and back, each going to one pair of sclerites. Two pairs of protergal muscles (fig. 3, *ptc*) arise from the pronotum below ridge *j* and go to the 1st cervical sclerite. The combined action of cephalic and protergal muscles will, by pulling each pair of cervical sclerites into a straighter line, result in pushing the head forward (Snodgrass 1929). The prosternal muscles (fig. 4, *pse*) pass from the sternal arm of one side to the 1st cervical sclerite of the opposite side; they may help in lateral movement of the head.

The protergal muscles of the cervical sclerites might, by increased contraction, help to bring about a depression of the dorsal carina, and the prosternals, by pulling on the prosternal arms, would probably help to increase the constriction of the pronotum. The cephalic muscles can have no effect on the shape of the pronotum.

3. *Muscles Moving the Prothorax in Relation to the Mesothorax.*

The pair of broad tergo-pleural intersegmental muscles (fig. 3, *tpi*) lie somewhat dorsally and extend from the intersegmental membrane to the posterior side of the dorsal part of the ridge *c*. The paired sterno-pleural intersegmental muscles (figs. 3, 4, *spi*) run obliquely from the prosternal arms to the sides of the mesothorax. The three remaining pairs are more ventrally placed: the 2nd ventral longitudinal muscles (2 *vl*) run between the prosternal and the mesosternal arms, and the 3rd and 4th ventral longitudinal pairs (3 *vl*, 4 *vl*) are attached to the 1st spina, the 3rd ending on the mesosternal arm, and the 4th on the 2nd spina.

The tergo-pleural and the sterno-pleural intersegmental muscles will, on simultaneous contraction, pull the prothorax back. The three ventral pairs, if they contract alone, will tilt it down, but in conjunction with the two former pairs will pull the whole prothorax back.

If the tergo-pleural intersegmental muscles are used more often they will help to depress the carina. The 2nd ventral longitudinal muscles together with the 1st ventral longitudinals (described above) would, if they contracted together, increase the constriction of the pronotum by pulling on the prosternal arm,

Fig. 3

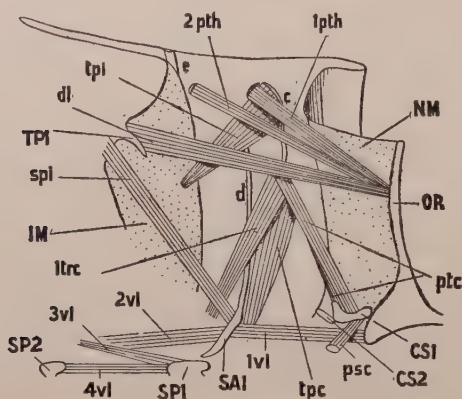
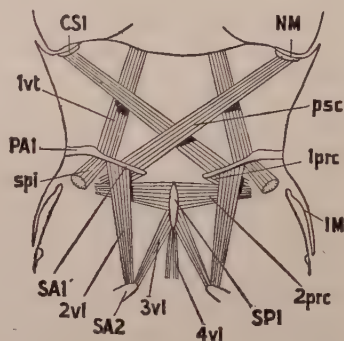


Fig. 4



FIGS. 3-4.—3. Inside view of the left side of pronotum of *ph. gregaria* showing some of the muscles. 4. Dorsal view of some of the more ventral muscles of the prothorax and mesothorax in *ph. gregaria*.—CS, cervical sclerite; dl, dorsal longitudinal muscle; IM, intersegmental membrane; NM, neck membrane; OR, occipital ridge; PA, pleural arm; ptc, protergal muscle of cervical sclerite; prc, posterior rotator of coxa; psc, prosternal muscle of 1st cervical sclerite; pth, protergal muscle of head; SA, sternal arm; SP, spina; spi, sternopleural intersegmental muscle; TP, thoracic phragma; tpc, tergal promotor of coxa; tpi, tergo-pleural intersegmental muscle; trc, tergal remotor of coxa; vl, ventral longitudinal muscle.

since they both pass obliquely inwards from this, the 1st going anteriorly and the 2nd posteriorly. The sterno-pleural muscles will, however, tend to counteract this, as they run dorsally and outwards from the sternal arm. The 3rd and 4th ventral longitudinals do not seem to affect the changes in shape of pronotum.

4. Muscles Moving the First Pair of Legs.

The only leg muscles that need be considered are those arising from the prothorax. These are the muscles moving the coxa and three branches of a large muscle moving the trochanter. The tergal promotor of the coxa (fig. 3, *tpc*), which pulls the leg forward, is inserted on the trochantin, a small skeletal plate lying just in front of the coxa, and has two branches in *Locusta*, though only one in *Dissosteira*. The inner branch arises a little below ridge *j*, and the outer below ridges *k k*.

There are three tergal remoters, all inserted on the posterior edge of the coxa. The 1st (fig. 3, *1 trc*) arises below ridge *j*, the 2nd below ridge *i* and the 3rd, a narrow muscle, arises more dorsally below ridge *h*. Extra contraction of the promotor or remoters will help to depress the carina, since they are all inserted on the pronotum below that part of the carina which is most raised in the phase *solitaria*.

The two pairs of posterior rotators of coxa, of which the 1st (fig. 4, *1 prc*)

arises on the sternal arm and the 2nd (2 *pre*) on the 1st spina, are also inserted on the posterior edge of the coxa. These seem to play no part in the observed phase changes.

The abductors of the coxa (not shown in the figures) are a pair of broad muscles each arising on the episternum and the anterior face of the pleural arm (in *Dissosteira* they arise from the episternum only). Each narrows to its insertion on the outer side of the coxa. The opposing muscle pair, the adductors of the coxa (not figured), pass from near the posterior side of the junction of the sternal and pleural arms to the inner edge of the coxa. The adductors, being inserted on the inner edge of the coxa, will tend to pull the pleural arms, and, therefore, the pronotum, inwards and thus to deepen the constriction. The abductors, being inserted on the outer edge, will have no such effect.

The depressor of the trochanter (not figured) has two of its branches arising from the coxa and three from the prothorax. Of the latter group, a large branch arises below ridge *h*, another fairly large one arises on the episternum and passes over the abductor of the coxa, and a third smaller one arises from the underside of the pleural arm. They are all inserted on a projection from the trochanter into the coxa. The first of these branches, arising somewhat dorsally, would, on increased contraction, help to lower the carina, and contraction of the second branch might have some effect on deepening the constriction.

MOVEMENTS LIKELY TO AFFECT PRONOTAL SHAPE.

The above discussion of the probable mechanical effects of the contraction of individual muscles on the development of the *ph. gregaria* characters may be summarised as follows:—

(A) *Lowering of pronotal carina* is induced by the action of (1) 1st and 2nd protergal muscles when the head is raised, or pulled back; (2) protergal muscles of cervical sclerites when the head is pushed forward; (3) tergo-pleural intersegmental muscles when the prothorax is pulled back; (4) promoters of the 1st legs; (5) remoters of 1st legs and (6) 1st branch of depressor of trochanter of 1st leg, which all take part in movements of the 1st leg.

(B) *Constriction of pronotum* is affected by the action of (1) prosternal muscles of the 1st cervical sclerites moving the head with regard to the prothorax; (2) 1st and 2nd ventral longitudinal muscles when the head and prothorax are moved down, or back; (3) possibly also the 2nd branch of the depressor of the trochanter involved in movement of the 1st leg.

(C) *Shortening of metazona* is affected by the action of protergal muscles which raise, or pull back, the head (and possibly also of the longitudinal dorsal muscles taking part in the same action).

It will be seen that the muscular contractions likely to be concerned in the variation of pronotal shape towards *ph. gregaria* are mainly those responsible for movements of the head and prothorax in relation to the body, and of the first pair of legs. Leg movements are obviously concerned with crawling, and a greater intensity of wandering, which is characteristic of the behaviour of *ph. gregaria*, would thus inevitably contribute to the morphological change. As regards movements of the head, which appear to play an even more important part, it might be suggested that a gregarious hopper passes relatively more time in wandering over the horizontal surface of the ground, where it requires more muscular exertion to support the head in position, than is needed for a solitary hopper sitting vertically on a plant, with the head resting on the thorax by the force of gravity; it must be remembered that the head of a hopper is very large in relation to the thorax and probably very heavy, being strongly chitinised.

This suggestion finds supporting evidence in the fact that most ground-living (geophilous) ACRIDIDAE are characterised by a depressed and constricted pronotum, while a high and non-constricted shape is typical of plant-climbing (phytophilous) species. It may also be argued that a gregarious hopper would obtain more exercise of the muscles moving the head in connection with its feeding, which should be more intensive owing to the greater intensity of its metabolism as compared with *ph. solitaria*.

In general, the modification of the pronotal skeleton by the action of muscles supporting and moving the head of a locust hopper is but one of the numberless illustrations of the principle that the "skeletal form brought about by growth is to a very large extent determined by mechanical considerations" (Thompson 1917 : 712). An analogous case amongst vertebrates is found in rhinoceroses, the grazing species of which differ from those feeding on tree branches by the greater development of the occipital crest, induced by the pull of the muscles supporting the head. The difference can even be produced in an individual, since a tree-feeding rhinoceros kept long in captivity and forced to feed from the ground may develop an abnormal occipital crest (Zeuner 1934). The fact that in a locust the muscular strain causes a depression of the pronotal carina and in a rhinoceros a greater development of the occipital crest, depends, of course, on the skeleton being external in the first case and internal in the second. The visible results are diametrically opposed, but the principle remains.

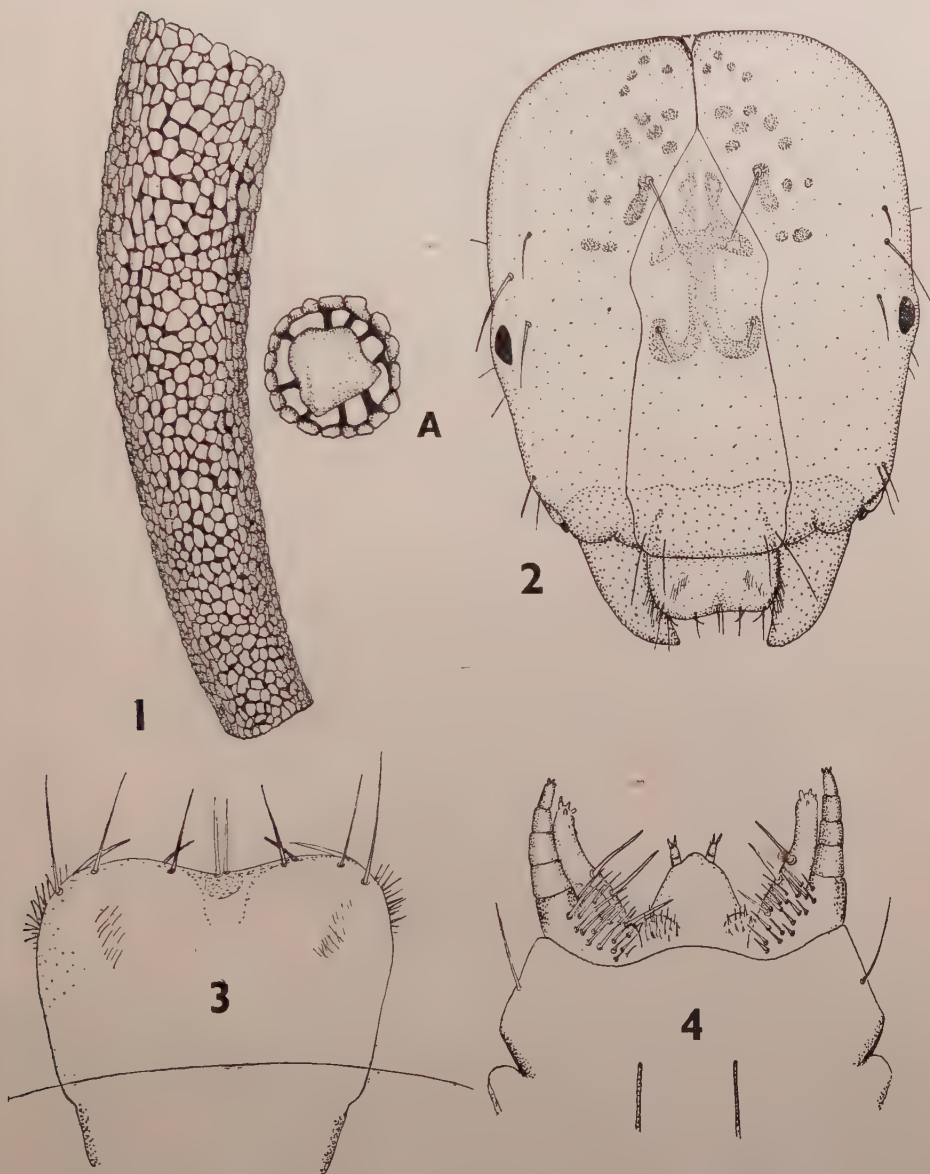
Thus, the phenomenon of individual phase change in the locust pronotum may be regarded as a striking example of a morphological response of a growing organism to a modification of behaviour caused by environmental factors. Seen in this light, the pronotal phase characters cease to be mere biometric deductions and receive a reasonable biological explanation. Further confirmation of this idea can be obtained through studies on the types of movements particularly characteristic of the *ph. gregaria* and *ph. solitaria*, respectively, and the present paper suggests that in such studies attention should be concentrated particularly on the movements of the head and of the first pair of legs. The above, of course, refers to the pronotal shape only; the development of other phase characters may be due to other causes.

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LARVAE OF THE BRITISH TRICHOPTERA. 5

By N. E. HICKIN, Ph.D, F.R.E.S.

Odontocerum albicorne Scopoli (ODONTOCERIDAE).

FIGS. 1-4.—*O. albicorne*. 1, larval case; a, view of posterior end of larval case; 2, head of larva; 3, labrum of larva; 4, maxillae and labium.

PROC. R. ENT. SOC. LOND. (A) 17. PTS. 10-12. (DECEMBER 1942.)

THE larva of this species inhabits swiftly-running streams with a rocky bottom, the specimens described below having been obtained from Dowles Brook, Bewdley, Worcestershire, a brook which, although practically at sea-level, has many characters of a subalpine stream. It is swiftly running over a rocky bed and there is no phanerogamic vegetation present. The water is cold even in summer, being shaded by dense woodland for many miles of its length.

Odontocerum albicorne is the sole British representative of the family ODONTOCERIDAE.

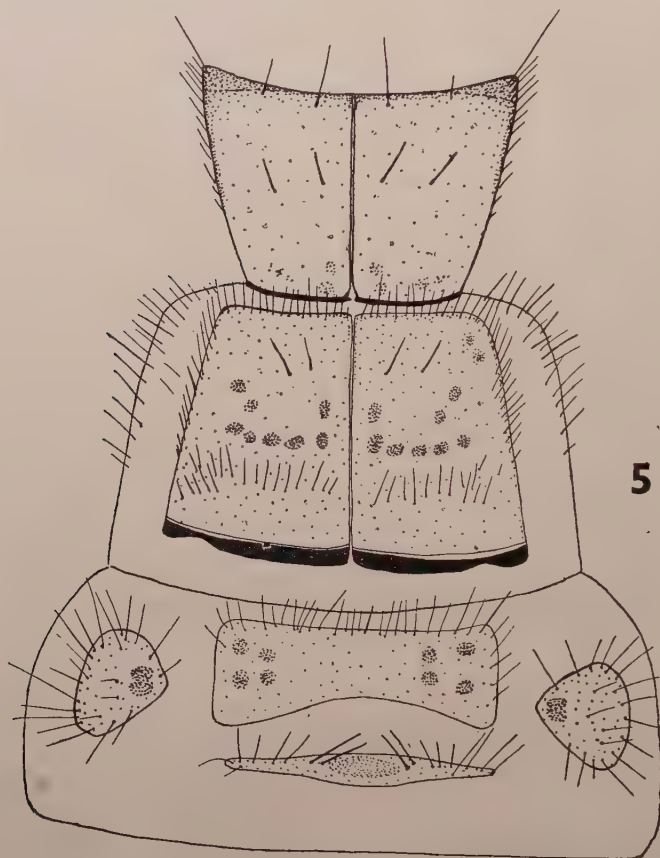
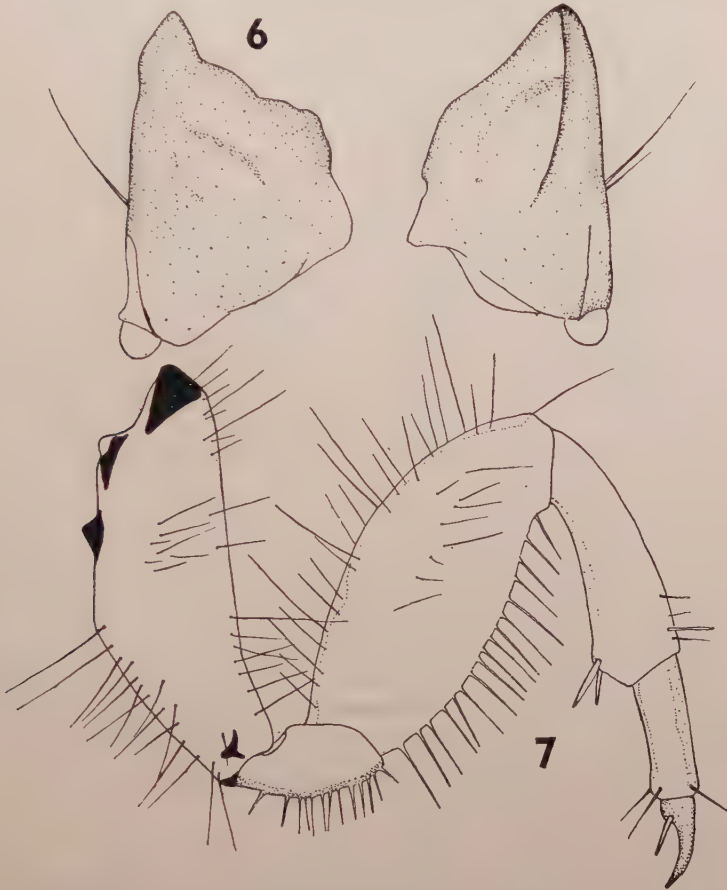


FIG. 5.—*O. albicorne*. Thorax of larva.

Case. The larval case is composed of a single layer of large grains of sand, the exterior having a fairly smooth texture. It is slightly curved and tapers towards the posterior end. One or several pebbles incompletely block the tail end, held in position by a web of dark brown secretion, and before pupation the head end is blocked also by a small pebble. Size: up to 20 mm. in length and 4 mm. in breadth at the larger end. *Larva:* the eruciform larva is cylindrical and is widest at the thorax. The sclerotised parts are light chestnut brown in colour whilst the abdomen is greyish-white. Size: up to 18 mm. in length and 3 mm. in breadth. *Head:* hypognathous, ovoid in shape with oral end slightly attenuate, light chestnut brown with outer edge of mandibles black. Clypeus elongate

with two slight concavities along each lateral margin, one smaller near the oral end and the larger, near the middle. At the aboral end of the clypeus is an anchor-shaped mark with the "eye" divided. A spine is borne at both oral apices of the mark whilst a light coloured spot is situated at each of the remaining four apices. Several groups of dark spots are situated on the frons near the aboral end of the clypeus and near the median frontal suture.



FIGS. 6-7.—*O. albicorne*. 6, mandibles of larva; 7, prothoracic leg of larva.

A spine projects from a single larger spot lying on each side of the aboral end of the clypeus. A group of three or four spines lies near each eye. *Mouth-parts*: labrum with anterior margin concave and small median sclerotised depression. Four pairs of bristles and two pairs of inwardly bent spines along anterior margin. *Mandibles*: wedged-shaped obtuse and slightly asymmetrical. Outer margin folded and heavily sclerotised. A few blunt teeth on the cutting edge more defined on the left than on the right. A group of bristles on the outer edge. *Maxillae*: maxillary lobe conical with three curved inwardly projecting spines lying along the inner edge. Many smaller spines at base of lobe. Maxillary palp four-segmented with insertion into lobe sclerotised, giving appearance of another segment. (Ulmer gives five segments, Rousseau four.) Labium conical, labial palps two-segmented. Two hairy lobes at base of labium. *Thorax*: pronotum sclerotised, concave

anteriorly for insertion of head. Hairy and darker in colour at the sides. Sclerotised portion of mesonotum consists of two large plates reaching laterally almost as far as pleural region. Posterior margin black. A few dark spots run transversely at about the middle, and just posterior to these is a transverse row of hairs. Anterior and outer margins of sclerotised plates hairy. Metanotum has four sclerotised patches. Two are transverse, lying one behind the other. The anterior patch is large, with its posterior margin deeply

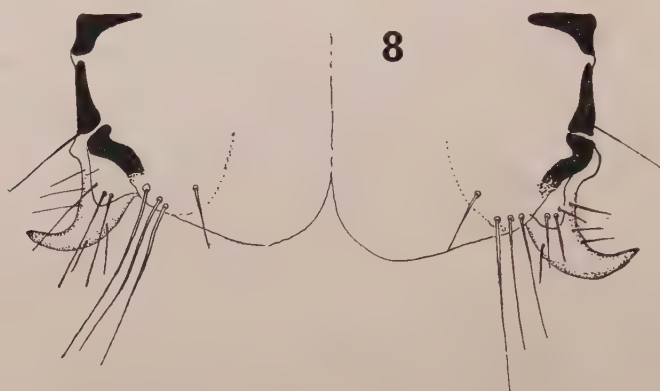


FIG. 8.—*O. albicorne*. Anal claws of larva.

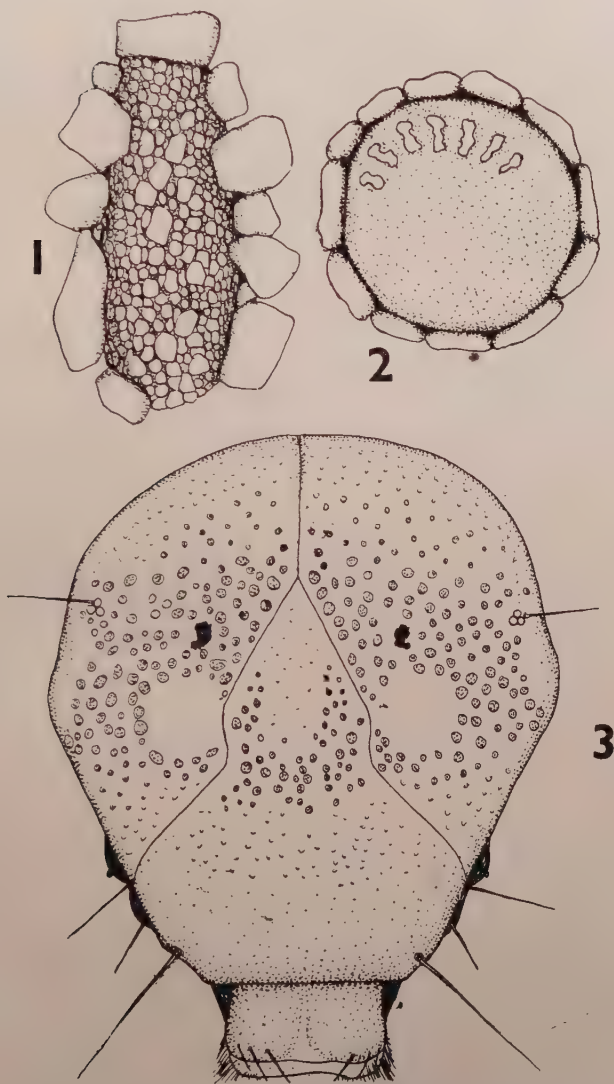
concave. Posterior patch narrow with anterior and posterior margins convex and with a large dark mark in the centre. A row of hairs runs transversely along this patch. The remaining pair of sclerites are lateral patches, one in each pleural region. They are hairy and each bears a dark mark in the region nearest the dorsal surface. *Legs*: approximately equal in size, shortest in front. Femur and tibia hairy, tarsus not so hairy. Tarsal claw long, with a basal spine. *Abdomen*: fairly large stump-like dorsal sucker on first segment, but lateral suckers much reduced. Gills filiform, arranged in circlets near anterior margin of each of segments II to VII. Lateral line weakly developed, formed of fine hairs. Anal claws small, of two segments, but supported by three sclerites black in colour. Three long bristles adjacent to the posterior sclerite.

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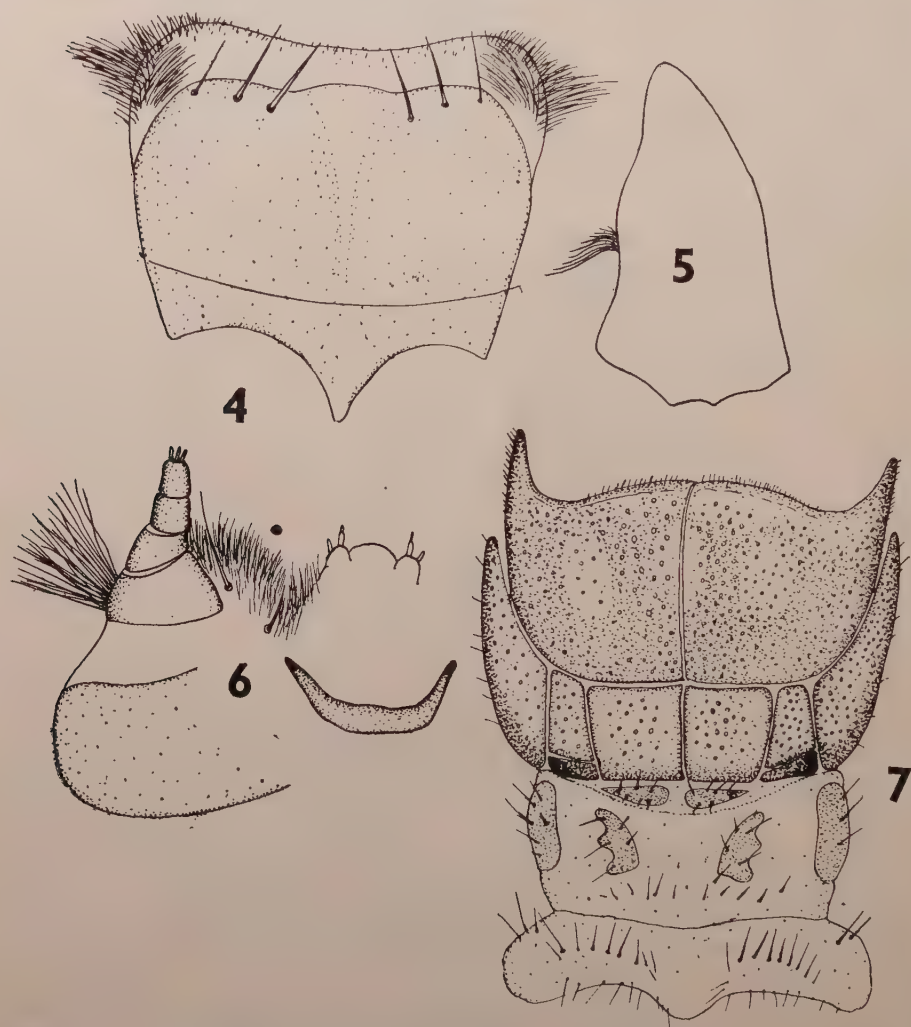
LARVAE OF THE BRITISH TRICHOPTERA. 6

By N. E. HICKIN, Ph.D., F.R.E.S.

Silo pallipes Fabricius (SERICOSTOMATIDAE).FIGS. 1-3.—*S. pallipes*. 1, case; 2, view of posterior end of pupal case; 3, head.

PROC. R. ENT. SOC. LOND. (A) 17. PTS. 10-12. (DECEMBER 1942.)

LARVAE were collected from a small, rapidly flowing stream at the edge of a beechwood at Cranham, Gloucestershire, where they were very plentiful. The stream was bordered with thick vegetation, and the bottom covered with small rocks and stones of limestone. A few larvae were reared to maturity.



FIGS. 4-7.—*S. pallipes*. 4, labrum; 5, mandible; 6, maxilla and labium; 7, thorax and first abdominal segment.

Case. A tubular portion of sand grains with small pebbles cemented along two sides giving dorsal and ventral surfaces to the case, ventral surface slightly flattened. Length 8 mm., breadth 4.5 mm. Shortly before pupation the anterior end is closed with a small stone, whilst at the posterior end the opening is filled with a dark brown secretion with the exception of a small lattice of about seven small slits arranged in an arc. *Larva*: cruciform, cylindrical with abdomen gradually tapering distally. Sclerotised parts uniformly dark brown. Pro- and mesothoracic nota sclerotised, forming a globular structure distinct

from the partially sclerotised metathoracic notum. *Head*: hypognathous, ovoid, tapering towards oral end. Angles on genae fairly sharp. Eyes small, set close together at front of head. Clypeus wide at the base. Antennae very much reduced. Head covered with small dark tubercles, except a small area at aboral end of clypeus and an area on each gena adjacent to this. The size of the tubercles decreases towards the top of the head, on the frons, and on the clypeus towards the labrum. Very few bristles present, one large pair at the base of the clypeus and three smaller pairs. One pair of the latter are lateral to the eyes and the other two pairs are lateral to the base of the clypeus. *Mouth-parts*: labrum of two parts, a proximal sclerotised part, with a median prolongation at the base and bearing three pairs of bristles transversely near the anterior margin, and a distal unsclerotised part having a brush of fine hairs on each side. Mandibles acute, with a bunch of fine hairs at about the middle of the inner edge a little nearer the base. Maxillary palps four-segmented with basal segments bulbous and brush of fine hairs emerging from the basal segment. Galea covered with fine hairs and bearing two bristles. Labium with fine hairs at the side, labial palps two-segmented with a tubercle on each segment. Bow-shaped sclerite at base of labium. *Thorax*: pro- and mesothoracic nota sclerotised, covered with small dark coloured tubercles. Pronotum dark reddish-brown with three light patches, one median, two lateral. Pronotum with median suture, convex, anterior margin fringed with small hairs. Pro- and mesonota have lateral wing-like extensions extending anteriorly.



FIGS. 8-9.—*S. pallipes*. 8, prothoracic leg; 9, anal claws.

Mesonotum lighter in colour than pronotum, divided into ten parts, by a median suture, two lateral longitudinal sutures and two transverse sutures on each side. The hinder of the outer pair of sclerites is not visible from the dorsal surface. Metanotum with six sclerotised patches; two small pear-shaped patches lie transversely near the mesonotum, with a pair of slightly larger patches lying posteriorly with sinuate margins. The largest patches occupy a position in the pleural region. All six sclerotised patches bear bristles. *Legs*: equal, tarsal claws strongly curved and with a basal spine. Anterior edge of femur with continuous dark mark. Prosternal horn present. *Abdomen*: first segment bulbous laterally and in centre of posterior margin. Branched gills present on the second to seventh segments inclusive. Lateral line reaching to the beginning of the eighth segment. Anal claws supported by single large sclerites having small extension pointing towards and almost meeting one small and three large bristles.

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BOOK NOTICE.

Insects and their stories. By H. HOOGSTRAAL. Obl. 8vo. New York. (Thomas Y. Crowell), 1941. pp. [viii] + 144, 98 figs. Price \$2.

The object of this book is to arouse a general interest in common insects which might be encountered by any person in America. Some 46 insects are described in general terms and an enlarged illustration is given of each with, in addition, a detail of some interesting part of the insect. The text, which is written in non-technical language, is intended “. . . to follow the career of each of these insects : where and how it breeds, what it eats, how long it lives and where, and what its importance is in our human world.” The book is printed by offset process and the text is in double column.

DIFFERENCES IN RESISTANCE TO TOXIC SUBSTANCES SHOWN BY DIFFERENT BODY COLOUR MUTANTS IN *DROSOPHILA* (DIPTERA)

By H. KALMUS.

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INTRODUCTION.

THE darkening of a dipteran's cuticle is due to a tanning process caused by polyphenols (Fraenkel and Rudall, 1940, Pryor 1940), resulting at the same time in its hardening and dehydration. One would expect this harder and darker cuticle to be less permeable to water than a light one. On this assumption, experiments were undertaken (Kalmus, 1941) to demonstrate that the lighter mutants of four *Drosophila* species die earlier and lose weight more rapidly than their wild type sibs, when starving in a dry atmosphere.

Differences in permeability of cuticles of various coloration need not be confined to water. In this paper it will be shown that the structural changes in the cuticle accompanying darkening decrease the permeability not only for various water-soluble substances, but also for mineral oils and oil-soluble substances. Inherited differences in resistance to toxic substances can provide the raw material for selection. Therefore the bearing of the results on problems of chemical selection, and in particular on industrial melanism, are briefly discussed.

MATERIAL.

The following stocks of *Drosophila melanogaster* and *D. pseudoobscura*, race A, were used in the experiments.

<i>D. melanogaster</i> :	oregon +,	wild type (+)
	yellow ^{39e} ,	a lighter mutant (y)
	black,	a dark mutant (b)
	ebony,	a dark mutant (e)
<i>D. pseudoobscura</i> :	wild type (+)	
	yellow,	a light mutant (y)

The mutants may be briefly described. The recessive gene yellow causes the absence of all black elements from the colour pattern of both species. As the wild type of *D. melanogaster* is yellow-brown with black stripes, the difference in appearance is not very striking, but in *pseudoobscura*, in which the wild type is dark, it is very conspicuous. The semi-dominant gene black in *D. melanogaster* increases the extent and intensity of a dark colour pattern on the thorax and other parts of the body and in the homozygous form causes a dark cloudy area on the wings, following the venation. The semi-dominant ebony causes a similar wing effect and a more general darkening of the whole body.

Crosses were cultured on the usual agar-maize-yeast medium, *D. melanogaster* directly in bottles, *D. pseudoobscura* being mated in tubes and transferred to bottles after one week.

Sibs differing only in one of the alleles in a chromosome which determines the cuticle colour were always obtained in the second generation. The procedure for *y*, which is sex-linked in both species, was as follows:—

$$p = \frac{y}{y} \text{♀} \times y^+ \text{♂}$$

$$F_1 = \frac{y}{y^+} \text{♀} \times y \text{♂}$$

$$F_2 = \frac{y}{y^+} \text{♀}, \frac{y}{y} \text{♀}, y^+ \text{♂}, y \text{♂}$$

Phenotypically half the females and half the males in the F_2 generation were wild type, the others being yellow.

The procedure for the autosomal gene *b* (and similarly *e*) was slightly different:—

$$p : \frac{b}{b} \text{♀} \times \frac{b^+}{b^+} \text{♂}$$

$$F_1 : \frac{b^+}{b} \text{♀} \times \frac{b^+}{b} \text{♂}$$

$$F_2 : \frac{b^+}{b^+} \text{♀}, \frac{b^+}{b} \text{♀}, \frac{b}{b} \text{♀}, \frac{b^+}{b^+} \text{♂}, \frac{b^+}{b} \text{♂}, \frac{b}{b} \text{♂}$$

The separation of the homozygous mutant quarter of F_2 from the rest is always easy for *b* and *e*, but, because they are semi-dominant, complete separation of the heterozygous half from the homozygous wild type (1 quarter) is impossible. It is therefore difficult to determine the differences of all three groups, and consequently a comparison was made between the homozygous mutants and the lightest individuals of the rest. It is quite possible that the inclusion of some heterozygotes in the experiments has decreased the difference in reactions observed.

For the experiments flies of known, and fairly uniform, age were used by collecting those which emerged during a specific period (1–2 days) from one or several bottles. They were then kept for several days in a bottle on fresh food.

TECHNIQUE.

For the experiments, groups of forty flies (ten each of wild type males, wild type females, mutant males and mutant females) were put in tubes stoppered with cotton wool. They were narcotised with CO_2 from a Kipp apparatus. Immobilisation was quickly attained, and lasted for 1–3 minutes. Directly after narcotisation the insects were placed in petri dishes 9 cm. in diameter and sprayed. The bottom of each petri dish was covered with tricoline, a textile material, to absorb excess spray fluid.

The chemicals were applied by means of an apparatus designed to administer controlled and uniform deposits of contact insecticides (Potter 1941). Major variations in deposit were obtained by varying the amount of fluid in the reservoir of the atomiser, and small corrections made by adjusting the pressure of the compressed air working the atomiser. The amount of the deposit of each of the fluids tested was controlled by weighings.

After spraying, the petri dishes were covered with muslin and kept in the

laboratory at temperatures of 18–20° C. and relative humidity 60–75%. The following substances were tested :—

(1) *Heavy mineral oil*. Specific gravity 0.880, viscosity Redwood I at 21° C. 104'', closed flash point 154° C., boiling range 10% at 298–319° C., 80% at 319–388° C., unsulphonated residue by volume 88%.

(2) *Light oil (kerosene)*. Specific gravity 0.795, closed flash point 46° C., initial boiling point 160° C., final boiling point 290° C., 35% distilling to 200° C.

(3) *Coal tar oil (creosote oil)*. Specific gravity 1.029, tar acids 16.5%, boiling range 20% at 220° C., 80% at 297° C. Applied as a 0.8% emulsion in water.

(4) *Pyrethrum extract*. Kenya flowers admixed with decolorising charcoal were extracted with petroleum ether to give an almost colourless solution. The petroleum ether was removed, the resin taken up with acetone, and diluted with 0.1% sulphonated loral to give a final spray solution containing 0.5 mg. of pyrethrin I and 10 ml. of acetone per 100 ml.

(5) *Sulphuric acid A.R. in water*.

The following criteria were used to assess the effect of the toxic substances :—

(1) survival; (2) loss of weight; (3) conspicuous collapse of the eyes.

SURVIVAL.

After treatment the flies were examined and placed in the categories, normal, moribund (*i.e.*, those only capable of moving their appendages), and those apparently dead. Differences in mortality between the wild type flies and the mutants were found after spraying with all the substances tested. The yellow mutants of both species showed a higher percentage mortality after a given time than the wild types. The dark mutants black and ebony in *D. melanogaster* survived longer than the wild type after treatment with heavy oil, but the difference between ebony and wild type was not significant. The mutant black survived longer than wild type after treatment with sulphuric acid. The results are given in Table 1.

TABLE 1.
Survival after spraying.

Treatment and species	Genetical constitution, sex and phenotype (5)	No. of replicates	Hours after spraying	Alive	Moribund	Dead	Alive in controls
1. Heavy mineral oil (1) 0.6 mg./cm. ² <i>D. pseudoobscura</i> race A	y ⁺ ♂ w.t.	4	6	33	2	5	40
	y ♂ l.			5	12	23	40
	y ⁺ ♀ w.t.			39	1	0	40
	y ♀ l.			7	11	22	40
	y ♀ l.						
2. Heavy mineral oil (1) 0.6 mg./cm. ² <i>D. melanogaster</i> or	y ⁺ ♂ w.t.	2	6	13	5	2	20
	y ♂ l.			0	7	13	20
	y ⁺ ♀ w.t.			10	6	4	20
	y ♀ l.			0	11	9	20
	y ♀ l.						
3. Heavy mineral oil (1) 0.3 mg./cm. ²	b ⁺ ♂ w.t.	3	18	4	3	23	30

TABLE 1 (continued).

Treatment and species	Genetical constitution, sex and phenotype (5)	No. of replicates	Hours after spraying	Alive	Moribund	Dead	Alive in controls
<i>D. melanogaster</i> or	$\frac{b}{b}$ ♂ d.			12	4	14	30
	$\frac{b^+}{b^+}$ ♀ w.t.			11	1	18	30
	$\frac{b}{b}$ ♀ d.			17	1	12	30
	$\frac{e^+}{e^+}$ ♂ w.t.			12	1	8	—
4. Heavy mineral oil (1) approx. 0.2 mg./cm. ² <i>D. melanogaster</i> or	$\frac{e}{e}$ ♂ d.	3	22	14	0	7	—
	$\frac{e^+}{e^+}$ ♀ w.t.			21	0	1	—
	$\frac{e^+}{e^+}$ ♀ d.			22	0	0	—
	$\frac{y^+}{y^+}$ ♂ w.t.			9	17	4	30
5. Kerosene (2) 0.2 mg./cm. ² <i>D. pseudoobscura</i> race A	$\frac{y}{y}$ ♂ l.	3	0.5	0	20	10	30
	$\frac{y}{y}$ ♀ w.t.			14	13	3	30
	$\frac{y}{y}$ ♀ l.			4	20	6	30
	$\frac{y^+}{y^+}$ ♂ w.t.			7	22	1	30
6. Coal-tar oil (3) emulsion 5 mg./cm. ² <i>D. pseudoobscura</i>	$\frac{y^+}{y^+}$ ♂ l.	3	6	2	19	9	30
	$\frac{y}{y}$ ♀ w.t.			12	17	1	30
	$\frac{y}{y}$ ♀ l.			5	16	9	30
	$\frac{y^+}{y^+}$ ♂ w.t.			11	14	5	29
7. Pyrethrum extract (4) 7 mg./cm. ² <i>D. pseudoobscura</i> race A	$\frac{y}{y}$ ♂ l.	3	19	5	16	9	25
	$\frac{y^+}{y^+}$ ♀ w.t.			17	8	5	30
	$\frac{y}{y}$ ♀ l.			8	16	9	29
	$\frac{y^+}{y^+}$ ♂ w.t.			16	4	10	20
8. Sulphuric acid (5) (0.01%) 5 mg./cm. ² <i>D. pseudoobscura</i> race A	$\frac{y}{y}$ ♂ l.	3	28	3	3	24	19
	$\frac{y^+}{y^+}$ ♀ w.t.			18	3	9	23
	$\frac{y}{y}$ ♀ l.			12	6	12	20
	$\frac{b^+}{b^+}$ ♂ w.t.			8	3	19	—
9. Sulphuric acid (5) (0.005%) 5 mg./cm. ² <i>D. melanogaster</i> or	$\frac{b}{b}$ ♂ d.	3	28	22	2	6	—
	$\frac{b^+}{b^+}$ ♀ w.t.			20	3	7	—
	$\frac{b}{b}$ ♀ d.			26	2	2	—
	$\frac{b^+}{b^+}$ ♂ w.t.			8	3	19	—

WEIGHING.

A differential loss of weight, presumably mainly water, of the dark and light specimens of four *Drosophila* species has previously been described (Kalmus 1941). A similar difference was established in these experiments after spraying with heavy or light oil. The loss of weight after spraying with the heavy oil was much quicker than in untreated controls and was even more rapid after treatment with the more volatile oil (Table 2). The technique used was the

same as in the survival experiments, but fewer individuals were treated. Weighings were made on a torsion balance of capacity 5 and sensitivity 0.01 mg.

TABLE 2.
Loss of weight of *D. pseudoobscura* race A.

Treatment	Genetical constitution, sex and phenotype	No. of individuals	Original weight mg.	No. dead after 2 hours	Average weight of all flies after 2 hours mg.	% of original weight	No. dead after 17 hours	Average weight of all flies after 17 hours mg.	% of original weight
Heavy mineral oil 0.3-0.4 mg./cm. ²	y ⁺ w.t.	8	1.01 ± 0.02	0	0.82 ± 0.03	82	2	0.74 ± 0.02	74
	y ♂ l.	8	0.84 ± 0.03	1	0.65 ± 0.01	77	6	0.49 ± 0.02	58
	y ⁺ w.t.	8	1.13 ± 0.03	0	1.03 ± 0.06	91	0	0.90 ± 0.06	79
	y ♀ l.	8	1.16 ± 0.07	1	1.00 ± 0.07	86	8	0.67 ± 0.07	58
Kerosene 0.2 mg./cm. ²	y ⁺ w.t.	7	0.93 ± 0.06	3	0.75 ± 0.06	81	5	0.62 ± 0.06	66
	y ♂ l.	8	0.82 ± 0.03	8	0.57 ± 0.02	70	8	0.38 ± 0.01	46
	y ⁺ w.t.	8	1.11 ± 0.06	0	0.87 ± 0.06	79	2	0.82 ± 0.05	74
	y ♀ l.	8	1.17 ± 0.06	4	0.84 ± 0.04	72	8	0.60 ± 0.04	51

COLLAPSE OF EYES.

After treatment of the flies with the more volatile mineral oil a curious effect was observed on the eyes after death. One or both eyes were collapsed, *i.e.*, their convex surface had become dented. The frequency of this occurrence was significantly greater in the yellow mutants of *D. pseudoobscura* than in the wild type (Table 3).

TABLE 3.

Collapse of eyes of offspring from a crossing of $\frac{y^+}{y} \times y$ in *D. pseudoobscura* race A.

Treatment	Genetical constitution, sex and phenotype			No. of individuals	No. alive	One eye collapsed	Both eyes collapsed
Kerosene 0.2 mg./cm. ²	y^+	♂	w.t.	30	0	2	16
Examination after 17 hours	y	♂	l.	30	0	2	26
	y^+	♀	w.t.	30	2	2	10
	y	♀	l.	30	0	1	22
	y	♀	l.	30	0	1	22

No collapse of eyes was observed after treatment with any of the other substances tested. Two factors are probably involved in this phenomenon. (a) the differential rate of desiccation, which diminished the body turgor and (b) a difference in the mechanical strength of the cornea and its softening by the light oil.

DISCUSSION.

It is not at present clear whether the differences in reaction of the mutants to all the chemicals used are due to a common cause. There may be a sequence of unknown factors resulting in a differential "general resistance" to the toxic substances which in the species tested is correlated with the cuticle colour. However, it is simplest to assume that a dark cuticle is less permeable to the substances tested than a lighter one. As the decrease in permeability of the darker forms applies to water and oil as well as to substances soluble in either of these agents, it is probably not due to the observed dehydration during darkening but to the formation of a firmer and stabler cuticular structure.

Dark and light mutants occur in many insect species. They are usually controlled by one or two genes. The following generalisations may therefore be of some heuristic value: greater protection against toxic substances conferred by a dark cuticle may become a selective advantage under various conditions, of which I will mention two only.

(1) Chemical selection may favour the survival of the darker members of an insect population that is subjected to treatment with insecticides. Thus a "resistant" race may develop in place of a former "susceptible" one.

(2) It may be the cause of industrial melanism, *i.e.*, the progressive replacements in industrial and urban districts of light individuals of many insect species, mainly Lepidoptera, by darker mutants. There is some indication that industry may affect the coloration of *Drosophila*. The analysis of Caucasian wild populations of *D. melanogaster* by Dubinin (1934) showed that the mutant gene ebony, which causes dark body colour and was also used in the present experiments, is present only in the neighbourhood of Batum, an industrial district, where 79% of the chromosomes tested carried it.

The dark colour of melanic Lepidoptera is principally localised in the scales and not in the cuticle proper. Therefore it might give less selective advantage. However, a very slight advantage carried by rather frequent single genes will spread at a rate comparable with those observed (Haldane 1924-32, Fisher 1930, Wright 1930). Up to the present only a few data published by Ford (1940) indicate that melanic offspring of starved families of the moth *Boarmia repandata* are hardier, *i.e.*, that they survive longer than the lighter sibs. Furthermore, Hovanitz (1941) found correlations between Lepidopteran coloration and climatic factors, such as temperature and humidity, which support the view that permeability for water at least is correlated with the colour of the scales. Unfortunately I am not able at present to work on Lepidoptera showing industrial melanism.

SUMMARY.

(1) The light mutant yellow in *Drosophila melanogaster* and *D. pseudoobscura*, race A, was less resistant than the darker wild type to spraying with heavy or light petroleum oils, a tar-oil emulsion in water, a pyrethrum extract and weak solutions of sulphuric acid. The dark mutant black in *D. melanogaster* showed a significantly greater survival than the wild type after spraying with heavy oil and sulphuric acid; the dark mutant ebony showed no significant differences.

(2) The yellow mutant of *D. pseudoobscura*, race A, lost significantly more weight after spraying with light and heavy oil than the wild type.

(3) A collapse of the eyes of the dead flies was noticed after treatment with the light oil. This was significantly more frequent in the yellow mutant of *D. pseudoobscura* than in the wild type.

(4) It is probable that the differences in reaction between individuals of different body colour may be due to differences in the permeability of the cuticles to the substances tested.

(5) The resistance of darker forms may become an advantage if insecticides of the type used are applied to an insect population and may thus cause the formation of a darker "resistant" population. This mechanism may also perhaps explain industrial melanism.

ACKNOWLEDGEMENTS.

I wish to thank Drs. J. T. Martin and C. Potter for the preparation of the sprays used and for their collaboration during the actual spraying. I am also indebted to Professor P. A. Buxton for the loan of the torsion balance and to Mr. N. K. Smith of the Murphy Chemical Company for the sample of tar oil. Finally I want to thank the Rockefeller Foundation, for without their grant these experiments could not have been carried out.

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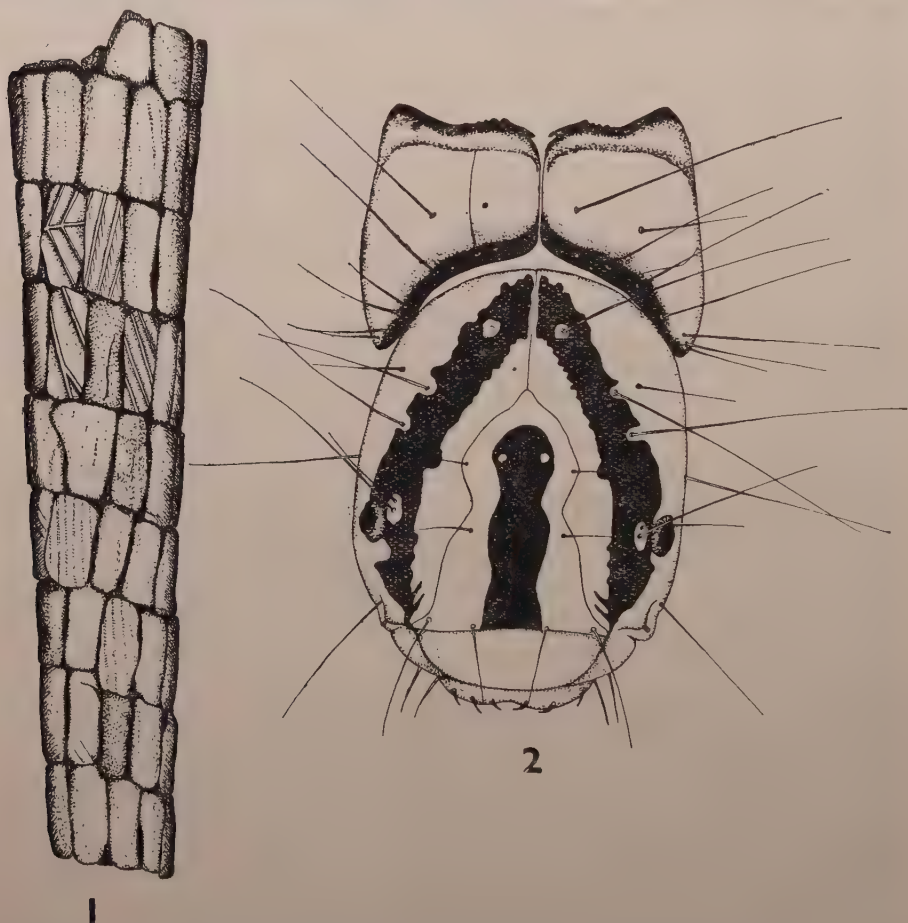
LARVAE OF THE BRITISH TRICHOPTERA. 7

By N. E. HICKIN, Ph.D., F.R.E.S.

Phryganea grandis L. (PHRYGANEIDAE).

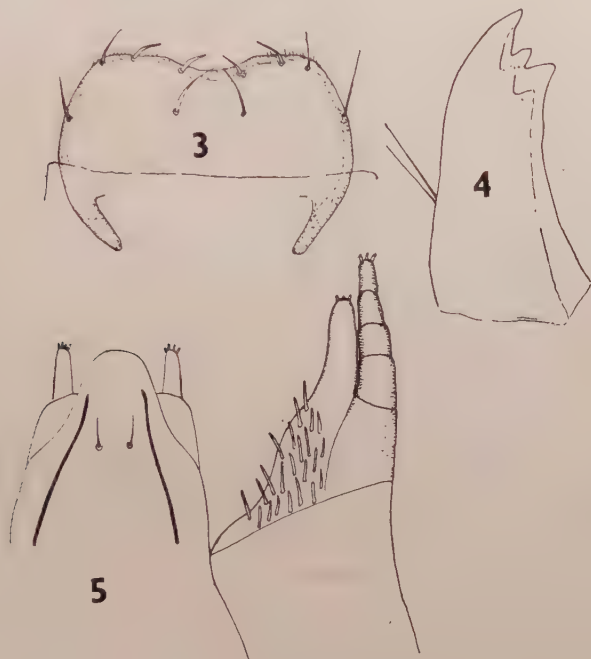
THE larva of this species is very large and is commonly met with in ponds, lakes and slow-moving rivers. The specimens from which the following description is made were collected from Kings Heath, Birmingham, and compared with larvae taken from Clay Pond, Wray, Windermere.

Case. 30–50 mm. long and 8–9 mm. wide. Made of fragments of leaves uniformly cut, arranged in a spiral whorl and tapering down to the distal end. When dragging its case along, the larva makes spasmodic jerking movements with the prothoracic legs



FIGS. 1–2.—*P. grandis*. 1, case; 2, head and prothorax.
PROC. R. ENT. SOC. LOND. (A) 17. PTS. 10–12. (DECEMBER 1942.)

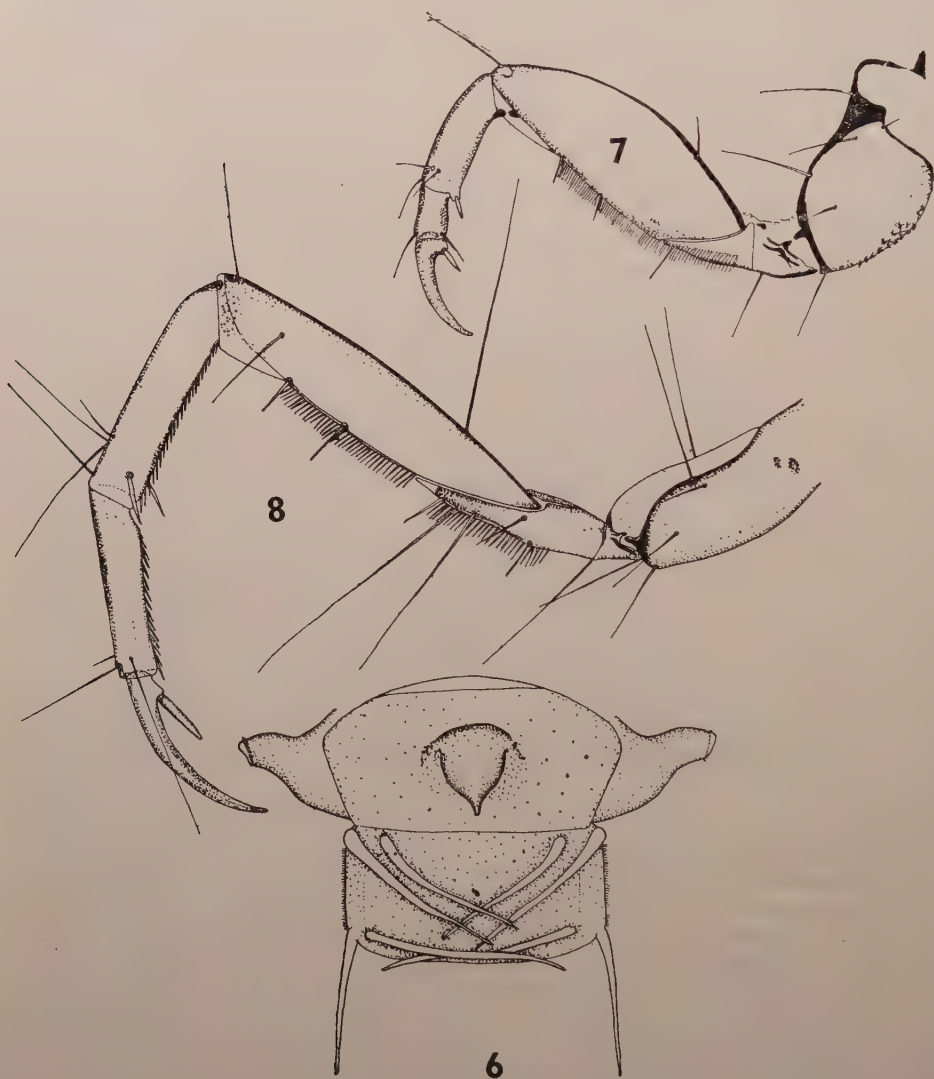
Larva: eruciform. The head is hypognathous and only the prothorax is sclerotised. With the exception of the legs the rest of the body is white. Length 30–40 mm., width 4–5 mm. *Head*: the head is bright yellow with two dark bands running over it from the anterior margin of the genae to cervical region of the frons, where they meet. These dark bands skirt the clypeus and appear as an inverted "V". A single dark band runs down the median line of the clypeus. Within the "V"-shaped band, two large bristles emerge from a yellow patch near the eye on each side. A pair of single bristles also emerges from this band posterior to the eyes. *Mouth-parts*: the labrum has the median part of the anterior margin concave. Six spines arise from this margin. A pair of spines also occupies a median position, with a spine on each lateral edge. The mandibles are three-toothed and



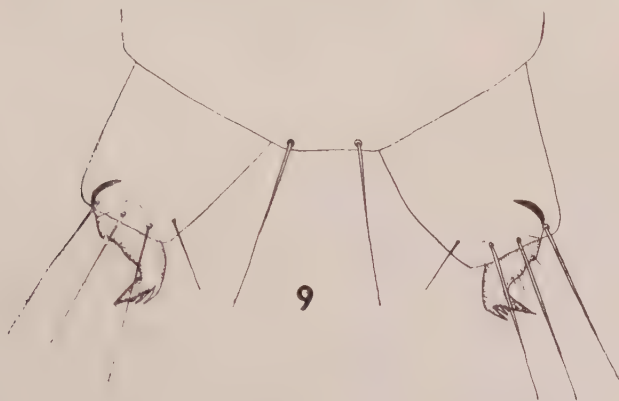
FIGS. 3–5.—*P. grandis*. 3, labrum; 4, mandibles; 5, labium and maxilla.

rather long. The left mandible has the teeth doubled. From the base of the maxillae arise a large number of blunt spines. The palp is five-segmented and the mala is palp-like, having a few tubercles at the distal end. The labial palps are distinct and have tubercles on the distal extremities. Two long bow-shaped sclerites are visible within the labium. *Thorax*: only the prothorax is sclerotised. It is bright yellow in colour with a transverse dark band across the anterior margin and another running across the posterior margin. A row of large bristles is set within the anterior band and a second row emerges across the centre of the prothorax transversely. A group of bristles occupies a lateral position on each side of the meso- and metathorax. *Legs*: a prosternal horn is present, *i.e.*, an unsclerotised finger-like prolongation of the prosternum lying between the femora of the prothoracic legs. Prothoracic legs shortest, mesothoracic slightly longer, whilst the metathoracic legs are considerably longer. In all legs the ventral margin of tibia and the distal part of the trochanter are edged with bristles between which lie small spines. The latter are also present on the tarsus of the meso- and metathoracic legs. In all legs a spur is

situated at the base of the tarsal claw. In the metathoracic leg the tarsal claw is very long. On the femur of prothoracic leg are a number of small scales edged with fine hairs. *Abdomen*: on the first abdominal segment is a large median process which is pointed and directed posteriorly and a pair of blunt lateral processes which curve forwards. The lateral processes have a circlet of small setae situated at their extremities. The remainder of the abdominal segments have filamentous gills. The eighth segment has only a single pair of gills—situated at the anterior pleural region of the segment. Anal claws with three auxiliary claws.



FIGS. 6-8.—*P. grandis*. 6, abdominal segments; 7, prothoracic leg; 8, metathoracic leg.

FIG. 9.—*P. grandis*. Anal claws.

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BOOK NOTICE.

Supplement to Insects of North Carolina. By C. S. BRIMLEY. 8vo. Raleigh, North Carolina. (North Carolina Department of Agriculture.) 1942. pp. 1-39.

In August, 1938, the *Insects of North Carolina* was published by the North Carolina Department of Agriculture, and since that time a number of species has been added and a few corrections made to the list. The present supplement brings the total number of insects recorded for North Carolina to 10,401, of which the chief are 3080 Coleoptera, 1970 Diptera, 1840 Hymenoptera, 1245 Lepidoptera, 659 Homoptera, and 516 Hemiptera.

BOOK NOTICE.

- I. The classification of the genus *Drosophila*, with descriptions of nine new species. By A. H. STURTEVANT.
- II. New species in the *quinaria* group of the subgenus *Drosophila*. By Warren P. SPENCER.
- III. Description of new species of the subgenera *Hirtodrosophila* and *Drosophila*. By J. T. PATTERSON and Marshall R. WHEELER.
8vo. Austin, Texas, U.S.A. (University of Texas Publication No. 4213). 1942. pp. 1-109.

The papers included in this publication are indicated by their titles. The first is an attempt to bring up to date work on the classification of *Drosophila*, but is not regarded as a final revision of that genus, since it is thought that a number of species remains undiscovered in the Nearctic region. The paper includes the description of nine new species, and is completed by a key to the North American species of the genus.

The second paper contains a description of six new species of *Drosophila* related to the *quinaria* group.

The third paper contains the description of thirty species in the subgenera *Hirtodrosophila* and *Drosophila*.

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The Fellowship and Fees

Fellows pay an Admission Fee of £3 3s. The Annual Contribution of £2 2s. is due on the first day of January in each year, and is payable in advance. Fellows under the age of 25 years may pay the entrance fee in three equal annual instalments.

Fees should be paid to the Treasurer, at 41, Queen's Gate, S.W.7, and *not to the Secretary*.

Fellows desiring to pay their Annual Contribution through their bankers may obtain an official form of banker's order by applying to the Treasurer.

Fellows whose Contributions for the current year have been paid are entitled to receive the *Transactions* and *Proceedings* of the Society free of charge. Further copies may be purchased at reduced prices by applying to the Registrar.

Forms of application for Fellowship, copies of the Bye-Laws and the List of Fellows may be obtained from the Registrar.

Meetings and Exhibitions

Fellows and others wishing to make a communication to a General Meeting of the Society are requested to send in their names, the title of their exhibit, and a short abstract of their remarks, to the Registrar fourteen days before the meeting at which it is proposed to make the communication. Should it be desirable to publish a fuller account of the communication the manuscript may be submitted for publication in *Proceedings Series A* or *Series B*. If the epidiascope is required, 24 hours' notice must be given. Objects for projection should not exceed 6 ins. by 6 ins.

Fellows resident abroad, or otherwise unable to attend meetings, are reminded that notes or observations sent to the Secretary may be communicated to a General Meeting on their behalf.